Offroad Semantic Scene Segmentation for Desert Autonomy

Team: Early Coder

Objective

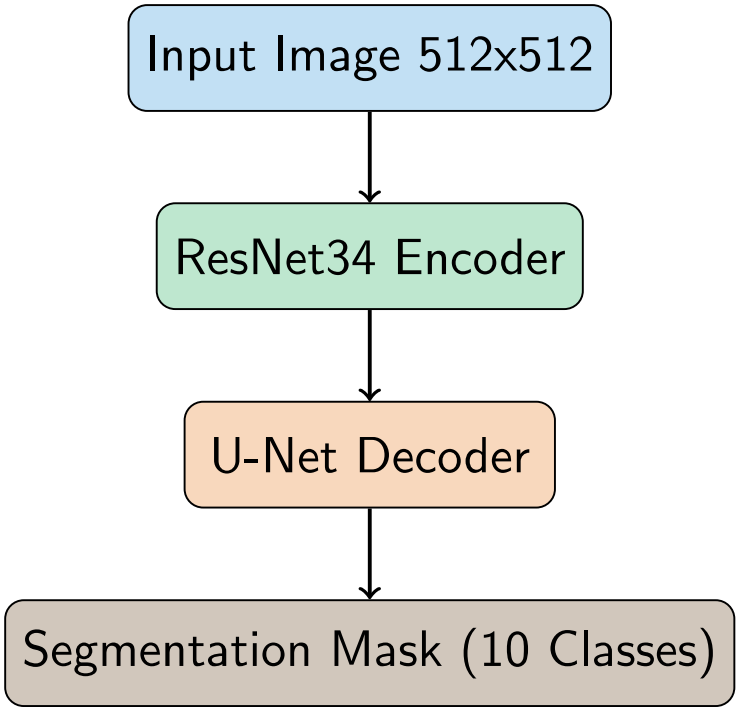
To develop a high-performance semantic segmentation model trained on synthetic desert data that generalizes effectively to unseen desert environments.

Methodology - Dataset

- Synthetic Desert Dataset
- Classes:
  - Trees
  - Lush Bushes
  - Dry Grass
  - Dry Bushes
  - Ground Clutter
  - Flowers
  - Logs
  - Rocks
  - Landscape
  - Sky
- Train / Validation / Test split strictly maintained

Model Architecture

Architecture: U-Net with ResNet34 Backbone



Preprocessing & Training Setup

Preprocessing

- Resize: 512x512
- Normalization
- Data Augmentation:
  - Horizontal Flip
  - Random Rotation
  - Brightness & Contrast
  - Random Crop

Training Setup

- Optimizer: Adam
- Learning Rate: 0.001
- Loss: Cross-Entropy + Dice Loss
- Batch Size: 8
- Epochs: 30

Results & Performance Metrics

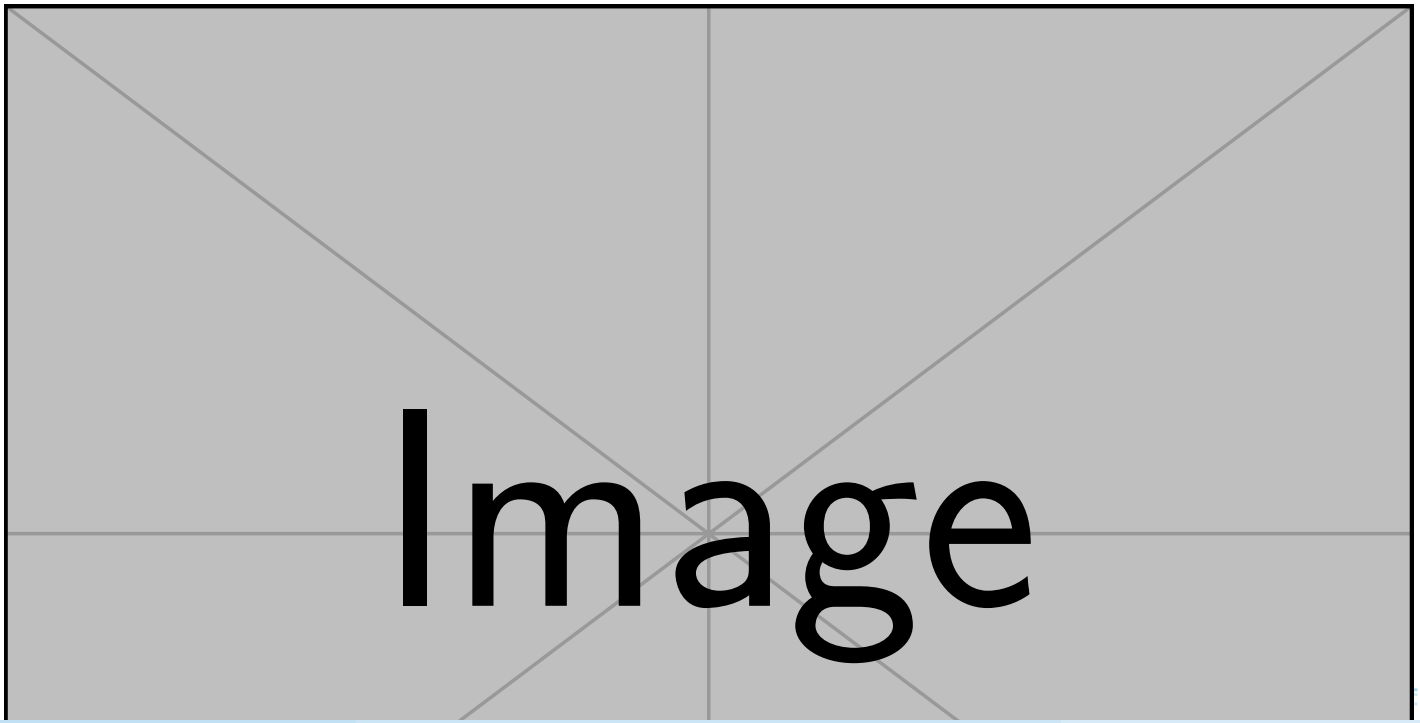
Metric	Score
Mean IoU	0.64
Pixel Accuracy	89%
Inference Speed	38 ms/image

Observations

- Sky and Landscape $\rightarrow$ Highest IoU
- Logs and Flowers $\rightarrow$ Lower IoU (small objects)
- Rocks confused with Ground Clutter

Training Behavior

- Loss decreased steadily
- Validation IoU stabilized after epoch 22
- Slight overfitting after epoch 25



Challenges & Solutions

Challenge 1: Class Imbalance

- Small objects underrepresented
- Solution: Weighted Loss + Focal Loss

Challenge 2: Texture Confusion

- Rocks vs Ground Clutter
- Solution: Stronger augmentation + Fine-tuning backbone

Challenge 3: Overfitting

- Solution: Early Stopping + Dropout + LR Reduction

Conclusion & Future Work

Conclusion

- Strong IoU performance on unseen desert environments
- Real-time inference capability
- Synthetic data proved effective for perception systems

Future Work

- Domain Adaptation to real desert images
- Self-supervised pretraining
- Multi-view segmentation
- Transformer-based models
- Lightweight optimization for edge devices

Thank You!